Operation and maintenance of bioretention and other stormwater infiltration practices - supplemental information

Green Infrastructure: Bioretention practices can be an important tool for retention and detention of stormwater runoff. Because they utilize vegetation, bioretention practices provide additional benefits, including cleaner air, carbon sequestration, improved biological habitat, and aesthetic value.

This page provides supplemental information on operation and maintenance (O&M) of bioretention and other stormwater infiltration practices. To see information on design phase, construction phase, and post-construction phase O&M, including inspection checklists, see the page called Operation and maintenance of bioretention and other stormwater infiltration practices.


Photo of an infiltration trench with native vegetation in Lino Lakes

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Erosion protection and sediment monitoring, removal, and disposal – protecting your investment

Regular inspection of not only the BMP but also the immediate surrounding catchment area is necessary to ensure a long lifespan of the water quality improvement feature. Erosion should be identified as soon as possible to avoid the contribution of significant sediment to the BMP.

Pretreatment devices need to be maintained for long-term functionality of the entire BMP. Accumulated sediment in forebays, filter strips, water quality sump catch basins, or any pretreatment features will need to be inspected yearly. Timing of cleaning of these features is dependent on their design and sediment storage capabilities. In watersheds with erosion or high sediment loadings, the frequency of clean out will likely be increased. A vacuum truck is typically used for sediment removal. It is possible that any sediment removed from pretreatment devices or from the bottom of a basin may contain high levels of pollutants. All sediments, similar to those retrieved from a stormwater pond during dredging, may be subjected to the MPCA's guidance for reuse and disposal (https://www.pca.state.mn.us/sites/default/files/wq-strm4-16.pdf).

If a grassed filter strip or swale is used as pretreatment, they should be mowed as frequently as a typical lawn. Depending on the contributing watershed, grassed BMPs may also need to be swept before mowing. All grassed BMPs should be swept annually with a stiff bristle broom or equal to remove thatch and winter sand. The University of Minnesota's Sustainable Urban Landscape Series website (http://www.extension.umn.edu/garden/landscaping/) provides guidance for turf maintenance, including mowing heights.

Sediment loading can potentially lead to a drop in infiltration or filtration rates. It is recommended that infiltration performance evaluations follow the four level assessment systems in Stormwater Treatment: Assessment and Maintenance (http://stormwaterbook.safl.umn.edu/) (Gulliver et al., 2010).

Seeding, planting, and landscaping maintenance – keeping it looking good

Plant selection during the design process is essential to limit the amount of maintenance required. It is also critical to identify who will be maintaining the BMP in perpetuity and to design the plantings or seedings accordingly. The decision to install containerized plants or to seed will dictate the appearance of the BMP for years to come. If the BMP is designed to be seeded with an appropriate native plant based seed mix, it is essential the owner have trained staff or the ability to hire specialized management professionals. Seedings can provide plant diversity and dense coverage that helps maintain drawdown rates, but landscape management professionals that have not been trained to identify and appropriately manage weeds within the seeding may inadvertently allow the BMP to become infested and the designed plant diversity be lost. The following are minimum requirements for seed establishment and plant coverage.

This bioretention basin utilizes several native species.

- At least 50 percent of specified vegetation cover at end of the first growing season, not including REQUIRED cover crop
- At least 90 percent of specified vegetation cover at end of the third growing season
- Supplement plantings to meet project specifications if cover requirements are not met

- Tailor percent coverage requirements to project goals and vegetation. For example, percent cover required for turf after one growing season would likely be 100 percent, whereas it would be lower for other vegetation types.

For information on plant selection, link here (http://stormwater.pca.state.mn.us/index.php/Minnesota_plant_lists).

For proper nutrient control, bioretention BMP's must not be fertilized unless a soil test from a certified lab indicates nutrient deficiency. An exception is a one-time fertilizer application during planting of the cell, which will help with plant establishment. Irrigation is also typically needed during establishment.

Weeding is especially important during the plant establishment period, when vegetation cover is not 100 percent yet. Some weeding will always be needed. It is also important to budget for some plant replacement (at least 5 to 10 percent of the original plantings or seedings) during the first few years in case some of the plants or seed that were originally installed don't become vigorous. It is highly recommended that the install contractor be responsible for a plant warranty period. Typically, plant warranty periods can be 60 days or up to one year from preliminary acceptance through final inspections. If budget allows, installing larger plants (#1 Cont. vs 4" Pot) during construction can decrease replacement rates if properly cared for during the establishment period.

Weeding in years after initial establishment should be targeted and thorough. Total eradication of aggressive weeds at each maintenance visit will ultimately reduce the overall effort required to keep the BMP weed free. Mulch is highly effective at preventing weeds from establishing while helping retain moisture for plant health. Mulch renewal will be needed two or three times after establishment (first five years). After that, the plants are typically dense enough to require less mulching, and the breakdown of plant material will provide enough organic matter to the infiltration/filtration practice.

Rubbish and trash removal will likely be needed more frequently than in the adjacent landscape. Trash removal is important for prevention of mosquitoes and for the overall appearance of the BMP.

Snow storage

BMP areas generally should not be used as dedicated snow storage areas, but can be with the following considerations.

- Snow storage should not occur in areas designated as potential stormwater hotspots for road salt (http://stormwater.pca.state.mn.us/index.php/Potential_stormwater_hotspots#Infiltration_guidance).
- Areas designed for infiltration should be protected from excessive snow storage where sand and salt is applied.
- Specific snow storage areas should be assigned that will provide some filtration before the stormwater reaches the BMP areas.**NOTE: Chloride will not be attenuated in filtration BMPs.**
- When used for snow storage, or if used to treat parking lot runoff, the BMP area should be planted with salt tolerant and non-woody plant species (http://stormwater.pca.state.mn.us/index.php/Minnesota_plant_lists).
- Practices should always be inspected for sand build-up on the surface following the spring melt event.

Sustainable service life for infiltration and bioretention BMPs

The service life of infiltration practices depends upon the pollutant of concern.

Infiltration rate service life before clogging

Infiltration rate appears to drop immediately after installation and then level off at a sustainable level (Jenkins et al. (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2010; Barrett et al. (http://www.deeproot.com/blog/blog-entries/the-role-of-trees-and-plants-in-bioretention), 2013). Planted bioretention columns even showed a slight increase in infiltration rate after the initial drop (Barrett et al., 2013). Plant roots are essential in macropore formation, which help to maintain the infiltration rate. If proper pretreatment is present, service life for infiltration should be unlimited. However, if construction site runoff is not kept from entering the infiltration cell, clogging will occur, limiting or eliminating the infiltration function of the system, thus requiring restorative maintenance or repair (Brown and Hunt (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2012).

Nitrogen reduction

An important mechanism of nitrogen removal in vegetated infiltration systems is plant uptake since nitrogen is essential for plant growth. If the BMP has an internal water storage zone, soluble nitrogen is also removed through denitrification, a microbially-mediated process that only occurs under anoxic conditions. Denitrification requires organic matter as a carbon source, which is supplied by decaying root matter and mulch. Particulate bound nitrogen in stormwater runoff will typically be removed through sedimentation. All of these processes are self-sustaining, and the service life of an infiltration system designed for nitrogen reduction should be very long. In oxygenated systems where denitrification is not an important process, leaching of nitrate is likely. In systems having soils with a high organic matter content, organic nitrogen can be converted to nitrate, resulting in additional loss of nitrogen through leaching (Liging and Davis (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2014).

Phosphorus reduction

With design optimized for phosphorus reduction, service life can be more than three decades (Lucas and Greenway (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2011c). Sediment bound phosphorus is removed through sedimentation, while removal of soluble phosphorus in bioretention depends on the type of media used. If the media is already saturated with P (i.e. its P binding sites are full), it will not be able to retain additional dissolved P and the P in stormwater will tend to leach from the media as it passes through the biofilter (Hunt et al. (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2006). It is highly recommended that the P-index of the media at installation be below 30, which equates to less than 36 milligrams per kilogram P, to ensure P removal capacity. Laboratory research has suggested an oxalate extractable P concentration of 20 to 40 milligrams per liter will provide consistent removal of P (O'Neill and Davis (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2012). After an effective loading of the equivalent of more than three decades of P into bioretention mecocosms optimized for P reduction, researchers in Australia showed that excellent P retention was still occurring. Keys to maximize P reduction in these systems included P sorptive soils or soil amendments (e.g. aluminum water treatment residuals [WTR] or Krasnozem soils [K40], a highly aggregated clay), use of coir peat (a source of organic matter low in phosphorus), and healthy vegetation. The systems with aluminum water treatment residuals still retained up to 99 percent of applied PO4-P in storm water after the equivalent of 32 years of treatment. After 110 weeks of effluent loading at typical stormwater concentrations, the equivalent of 48 years of bioretention loads, phosphate retention from storm water by the K40 soils treatment was 85 percent. "Comparison with the K40 treatments over the loading and dosing regimes suggest that the WTR treatments will perform at least as well as the K40 treatment under similar exposure of 48 years" (Lucas and Greenway (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2011).

Heavy metals retention

Metals are typically retained in infiltration systems through sedimentation and adsorption processes. Since there are a finite amount of sorption sites for metals in a particular soil, there will be a finite service life for the removal of dissolved metals. Morgan et al. (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References) (2011) investigated cadmium, copper, and zinc removal and retention with batch and column experiments. Using synthetic stormwater at typical stormwater concentrations, they found that 6 inches of filter media composed of 30 percent compost and 70 percent sand will last 95 years until breakthrough (i.e. when the effluent concentration is 10 percent of the influent concentration). They also found that increasing compost from 0 percent to 10 percent more than doubles the expected lifespan for 10 percent breakthrough in 6 inches of filter media for retainage of cadmium and zinc. Using accelerated dosing laboratory experiments, Hatt et al. (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References) (2011) found that breakthrough of Zn was observed after 2000 pore volumes, but did not observe breakthrough for Cd, Cu, and Pb after 15 years of synthetic stormwater passed through the media. However, concentrations of Cd, Cu, and Pb on soil media particles exceeded human and/or ecological health levels, which could have an impact on disposal if the media needed replacement. Since the majority of metals retainage occurs in the upper 2 to 4 inches of the soil media (Li and Davis (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2008), long-term metals capture may only require rejuvenation of the upper portion of the media.

Polycyclic aromatic hydrocarbons (PAHs) reduction

Accumulation of polycyclic aromatic hydrocarbons (PAHs) in sediments has been found to be so high in some stormwater retention ponds that disposal costs for the dredging spoils were prohibitively high. Research has shown that rain gardens, on the other hand, are “a viable solution for sustainable petroleum hydrocarbon removal from stormwater, and that vegetation can enhance overall performance and stimulate biodegradation.” (Lefevre (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2012b).

Maintenance agreements

A Maintenance Agreement is a legally binding agreement between two parties, and is defined as ”a nonpossessory right to use and/or enter onto the real property of another without possessing it.“ Maintenance Agreements are often required for the issuance of a permit for construction of a stormwater management feature and are written and approved by legal counsel. Maintenance Agreements are often similar to Construction Easements. A Maintenance Agreement is required for one party to define and enforce maintenance by another party. The Agreement also defines site access and maintenance of any features or infrastructure if the property owner fails to perform the required maintenance.

Maintenance Agreements are commonly established for a defined period such as five years for a residential site or 10 to 20 years for a commercial/governmental site after construction of the infiltration practice. Maintenance agreements often define the types of inspection and maintenance that would be required for that infiltration practice and what the timing and duration of the inspections and maintenance may be. Essential inspection and maintenance activities include but are not limited to drawdown time, sediment removal, erosion monitoring and correction, and vegetative maintenance and weeding. If maintenance is required to be performed due to failure of the site owner to properly maintain the infiltration practices, payment or reimbursement terms of the maintenance work are defined in the Agreement. Below is an example list of maintenance standards from an actual Maintenance Agreement.

1. Plants shall be watered daily for two weeks after the garden installation is complete.
2. In the first year, rainwater gardens require vigilant weeding and should be weeded monthly. The need for weeding will decrease as plants become established.
3. Dead plant material and garbage or other debris shall be removed from the rain garden.

4. Areas devoid of mulch shall be re-mulched on an annual basis.
5. The rainwater garden shall be inspected annually for sediment trapped in the pretreatment area and in the garden itself. If possible, accumulated sediment should be removed.
6. Shrubs shall be pruned as necessary to keep a neat appearance.
7. Plants that do not survive shall be removed and replanted.
8. Side slopes must be inspected for erosion and the formation of rills or gullies at least annually and erosion problems must be corrected immediately.
9. If gardens are properly planned and designed (protected from sediment and compaction and incorporating a sufficient turf pretreatment area), a rainwater basin is likely to retain its effectiveness for well over 20 years. After that time, inspection will reveal whether sedimentation warrants scraping out the basin and replanting it (possibly with salvaged plants).

In some project areas, a drainage easement may be required. Having an easement provides a mechanism for enforcement of maintenance agreements to help ensure infiltration practices are maintained and functioning. Drainage Easements also require that the land use not be altered in the future. Drainage Easements exist in perpetuity and are required property deed amendment to be passed down to all future property owners.

As defined by the Maintenance Agreement, the landowner should agree to provide notification immediately upon any change of the legal status or ownership of the property. Copies of all duly executed property transfer documents should be submitted as soon as a property transfer is made final.

- Example Maintenance Agreement 1
- Example Maintenance Agreement 2
- Example Maintenance Agreement 3

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